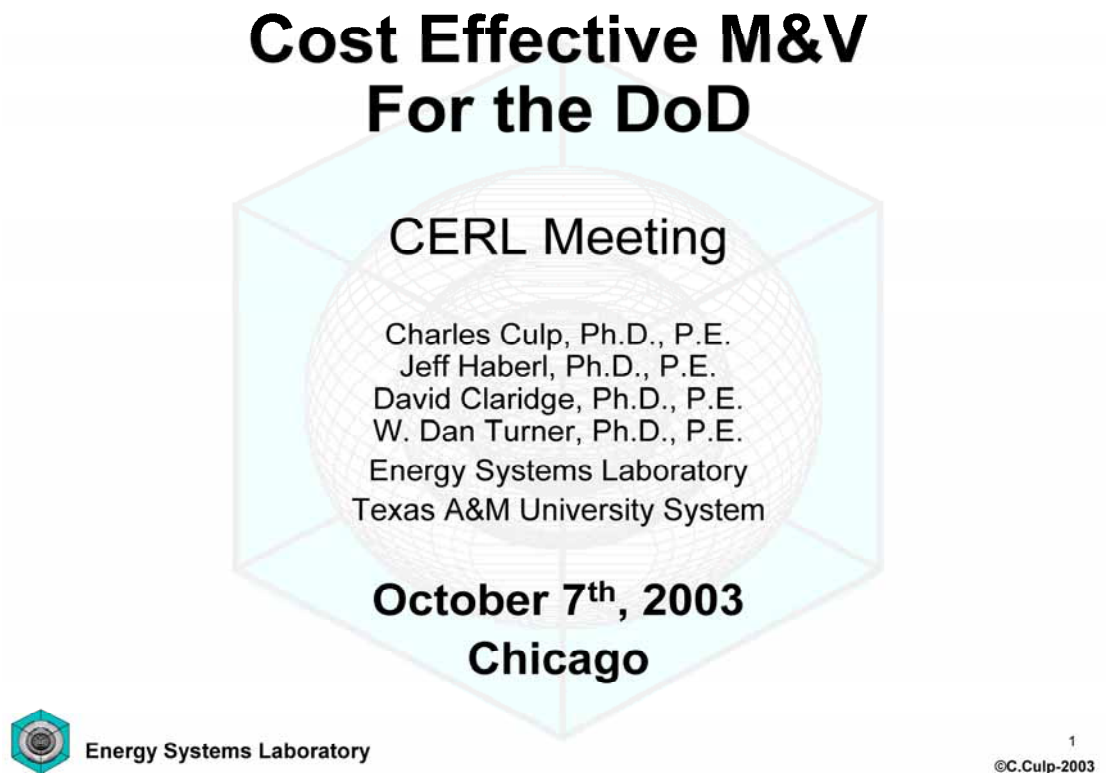
6 Session 4: LCCA, Measuring and Verification

Cost Effective M&V for the Department of Defense

Presenter: Dr. Charles Culp. Texas A&M University, ESL.



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See also ADM001864, Building Energy Performance Improvement Through Advanced Technologies, Smart Organization, and Financing. Proceedings of the Industry Workshop Held in Chicago, IL on 7-8 October 2003. , The original document contains color images.

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M&V History
M&V Strategy
M&V Examples

M&V History

- ESL is a major contributor to the IPMVP – "International Performance Measurement and Verification Protocol"
- ESL was heavily involved with ASHRAE's Guideline 14 – "Measurement of Energy and Demand Savings"
- Currently working with Texas State Agencies to introduce measurement based M&V into their ESCO programs
- Performing ESCO reviews for USAF and US Army
- Defining standard M&V methods for 18 Energy Conservation Projects (ECPs) for USAF

M&V History

- In the past, most USAF ESCO contracts were stipulated
  - This means that the USAF Installation agreed that the savings were met for the 20+ year contract at the time of contract signing
  - The USAF then assumed all risk for achieving savings
  - Finding many problems with accuracy of guarantees
  - If savings were not met, no budget existed to make up short-fall
- Projects in the DoD today are often stipulated

M&V Strategies

- Standard M&V methods being introduced to accelerate ESCO growth in USAF
  - Less review required
  - Faster turnaround and approval
  - Targeted for the "80% solution"
- Growing pains being experienced as the USAF and ESCOs implement monitoring
  - M&V cost target ~ 5% of the savings
  - Saves USAF from experiencing 30%+ drop in savings

M&V Strategies

- USAF ESCO contracts are evolving based on cost-effective measurement
  - This means that the USAF Installation and the ESCO share the risk of energy and savings performance
  - The USAF will typically assume the operational "amount of use" risk
  - The ESCO will typically have the equipment performance risk

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M&V Examples

- Standard M&V Plan (18) Guidelines
  - District Heating*
  - Lighting*
  - Constant Load Motors*
  - Variable Speed Drives*
  - Boiler Replacement*
  - Infrared Heating
  - Steam Traps
  - Chiller Replacement*
  - Cooling Tower Replacement
  - Plate Heat Exchanger
  - DX Heat Pump
  - EMCS*
  - FM Control Systems
  - Chiller Plant*
  - Building Envelope
  - Propane Air*
  - HVAC Controls
  - Thermal Storage

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* ~ 90% Complete

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M&V Example - Lighting

- Lighting
  - Key risks are:
    - Installing wrong or under / over lit fixtures / ballasts
    - Replacing the lamp / ballast with a low efficiency unit
    - Calculating the savings incorrectly due to:
      - Incorrect operating hours
      - Incorrect rate structure
      - Incorrect calculations
      - Incorrect demand calculations
  - M&V Plan is designed to prevent these risks from eroding savings

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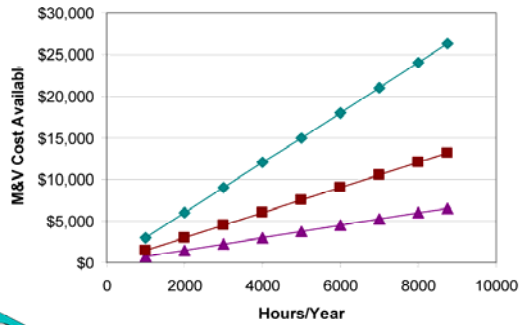
M&V Example - Lighting

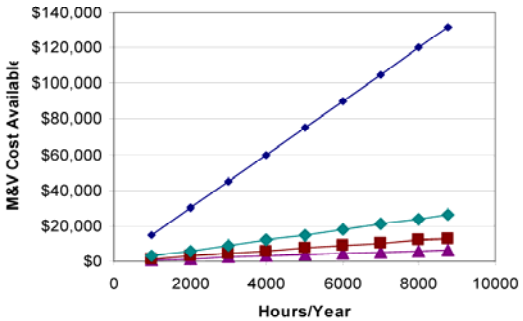
1 MW Consumption (10,000 fixtures at 100 W/fixture)

Operation Hrs/yr	Consumption $/yr @ $.05/kWh	Savings / yr @ 30%	M&V $ 5%	M&V $ 10%	M&V $ 20%
1000	$50,000	$15,000	$750	$1,500	$3,000
2000	$100,000	$30,000	$1,500	$3,000	$6,000
3000	$150,000	$45,000	$2,250	$4,500	$9,000
4000	$200,000	$60,000	$3,000	$6,000	$12,000
5000	$250,000	$75,000	$3,750	$7,500	$15,000
6000	$300,000	$90,000	$4,500	$9,000	$18,000
7000	$350,000	$105,000	$5,250	$10,500	$21,000
8000	$400,000	$120,000	$6,000	$12,000	$24,000
8760	$438,000	$131,400	$6,570	$13,140	$26,280

Cost Available for M&V



Savings Amount and M&V Cost



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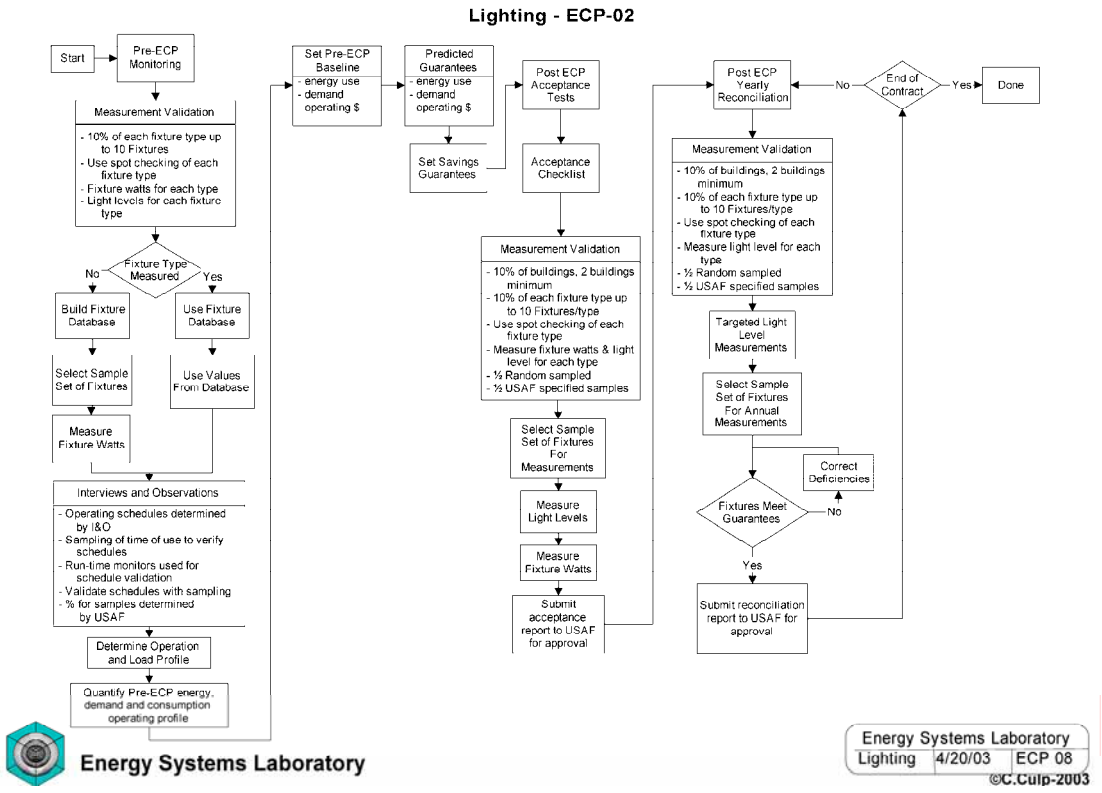
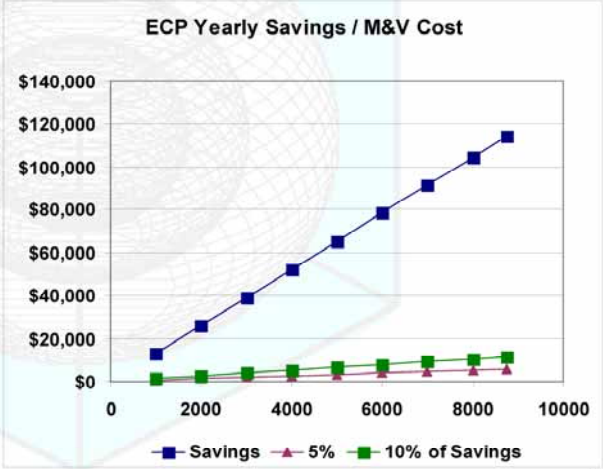


M&V Example - VSDs

- Variable Speed Drive Retrofit Example
  - Key risks are:
    - Disabling the VSD control and operating at 100%
    - Not repairing a dysfunctional control element or VSD Inverter
    - Results in $0 savings for that motor application
  - M&V Plan designed to prevent these risks from eroding savings

M&V Example - VSDs

- Variable Speed Drive Retrofit Example
  - Can save substantial energy and maintain comfort
  - For a VSD Retrofit with 10 motors at 50 HP
    - Savings estimated at $114,000 at 8760 hours per year
    - M&V target cost in the range of $3,000 to $12,000 per year (3% to 10%)



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M&V Example - VSDs

- Variable Speed Drive Retrofit Example
  - Lost savings often accumulate at 10%-20% / year
  - For a VSD Retrofit with 10 motors at 50 HP
    - Losses from not performing M&V could exceed $600,000 in first 10 years
    - M&V Costs at 10% per year are $114,000 over the 10 years
    - Automating M&V can further reduce cost of M&V

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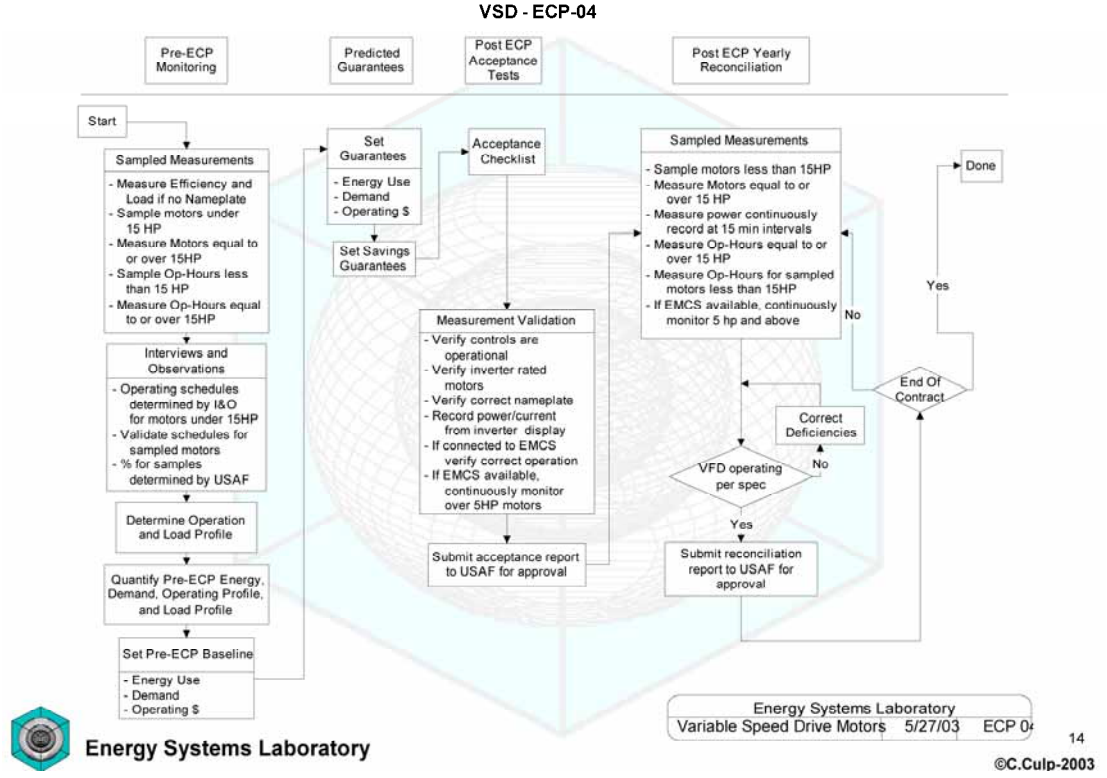

M&V Example - EMCSs

- Energy Management and Control Systems
  - Usually under-used as a Start/Stop Control
  - Operators need better training to effectively use full capabilities
  - Full capabilities allow
    - Optimum Start
    - Chiller Resets
    - Boiler Resets
    - AHU Controls
    - Box Controls
  - These are low sustainability measures which require on-going M&V

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M&V Example - EMCSs

- Energy Management and Control Systems
  - Key risks are:
    - Underestimating occupancy schedules
    - Not re-enabling temporary overrides
    - Occupant discomfort resulting in overrides
    - Disabling controls, overriding schedules and operating at 100%
    - Not repairing a dysfunctional control elements
  - M&V Plan designed to prevent these risks from eroding savings

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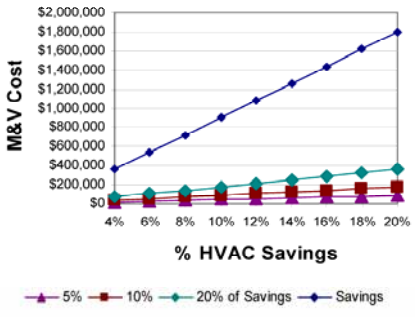
M&V Example - EMCSs

Energy Management and Control System

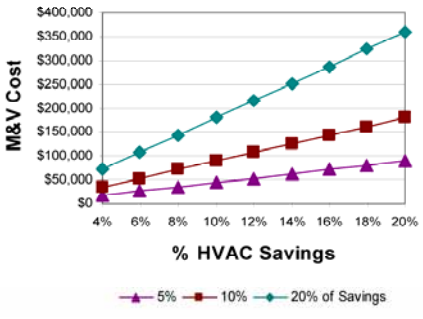
~6,000,000 sq ft - 40 Buildings at ~$1.50 / sqft

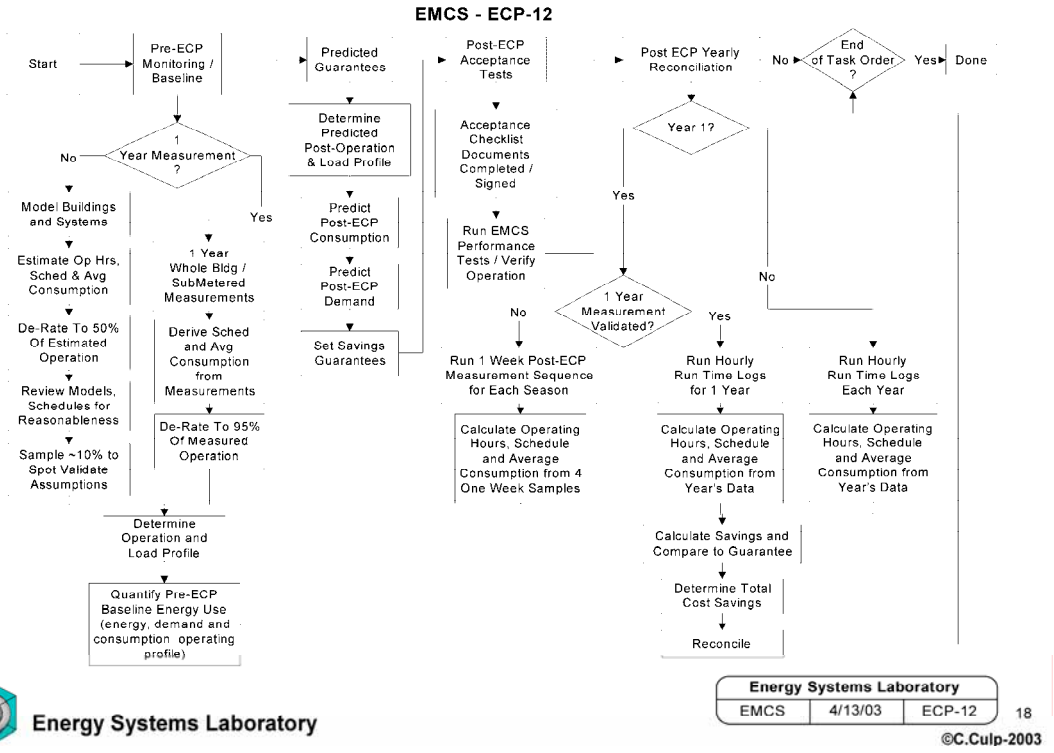
HVAC Savings %	Savings $/yr Estimate	M&V $ 5%	M&V $ 10%	M&V $ 20%
4%	$360,000	$18,000	$36,000	$72,000
6%	$540,000	$27,000	$54,000	$108,000
8%	$720,000	$36,000	$72,000	$144,000
10%	$900,000	$45,000	$90,000	$180,000
12%	$1,080,000	$54,000	$108,000	$216,000
14%	$1,260,000	$63,000	$126,000	$252,000
16%	$1,440,000	$72,000	$144,000	$288,000
18%	$1,620,000	$81,000	$162,000	$324,000
20%	$1,800,000	$90,000	$180,000	$360,000

EMCS M&V Cost per Year



EMCS M&V Cost per Year



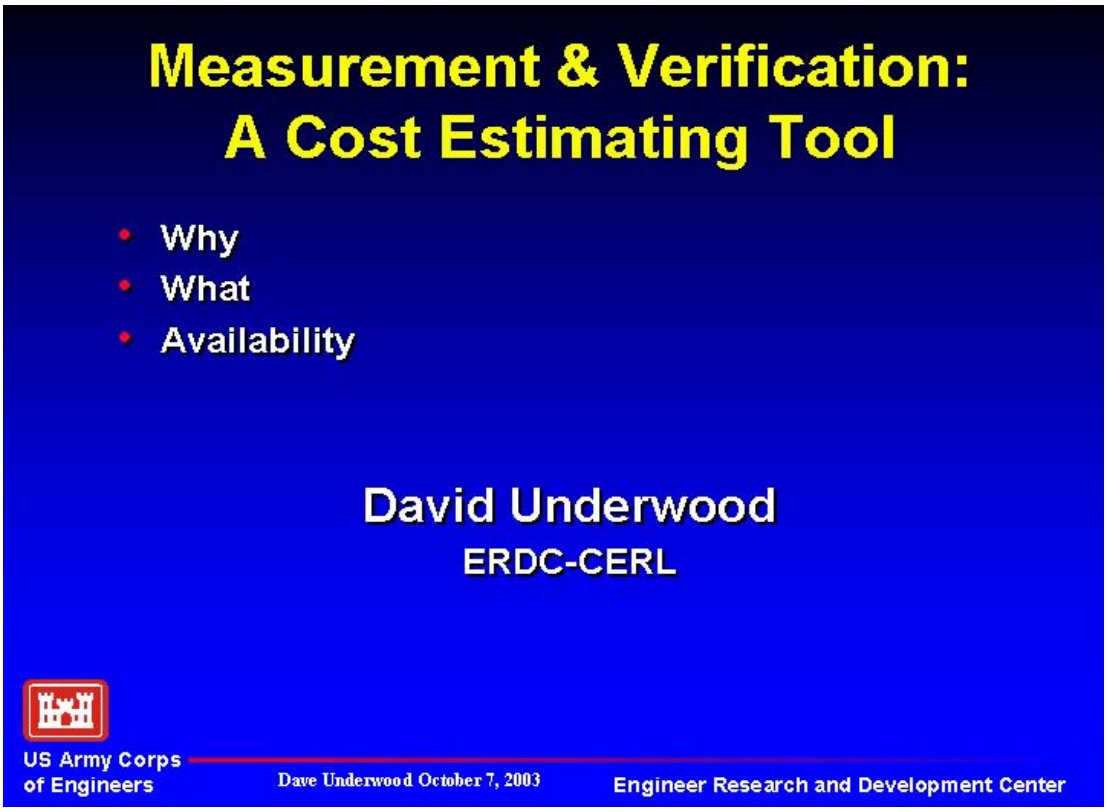


Summary

- Measurement and Verification is needed to sustain savings
- M&V must be cost effective over the life of the contract
- M&V must be straightforward and address the key short and long term risks of losing savings

A Tool for M+V Cost Estimating

Presenter: Mr. David Underwood. ERDC CERL.



Why An M&V Cost Estimating Tool

- Research of past ESPCs indicated a lack of sufficient M&V planning
- M&V Cost typically rolled into a single Number with no documentation on specifics
- Available tools were seen as insufficient
- Contractors cost estimating methods don't tend to make M&V costing detail available

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What M&V Cost Tool Is

- Basically a database with a user interface
  - A set of linked Excel Spreadsheets, Macros, and examples
  - Default costs which and can be changed
  - Reports with yearly, total life, and itemized costs
  - A resource for comparing various M&V scenarios
  - A resource for M&V equipment ordering

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What M&V Cost Tool Is

- Four Categories Based On Data Used For Analysis
  - Utility Billing
  - Short Term Data Acquisition (3 Types)
  - Long Term Data Acquisition (3 Types)
  - Calibrated Simulation

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"Hidden" Costs Included

- Labor
  - Data Sorting
  - Weather Data Purchasing and Processing
  - Modeling
  - Report Generation
  - Etc.
- Data Logger Maintenance and Removal

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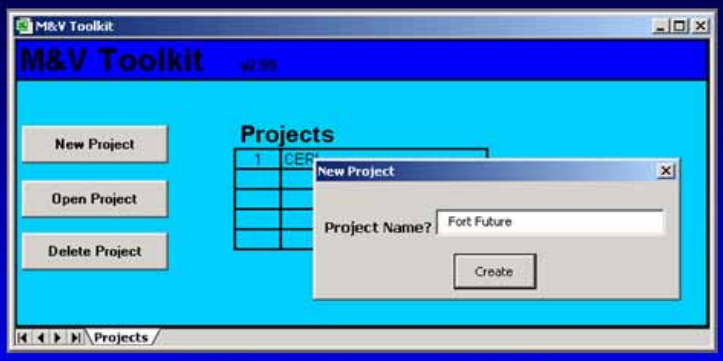
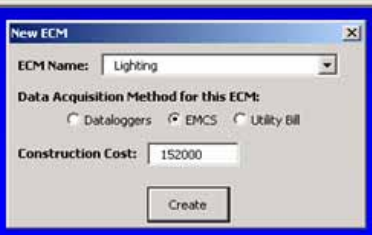
Creating Projects & ECMs





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Reports

- Equipment
- Labor
- Travel
- Weather
- Yearly
- Total

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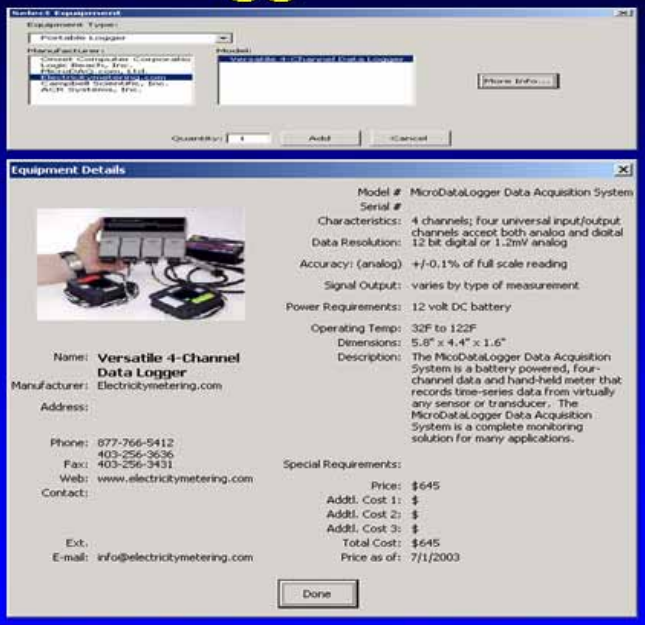
Data Logger Selection



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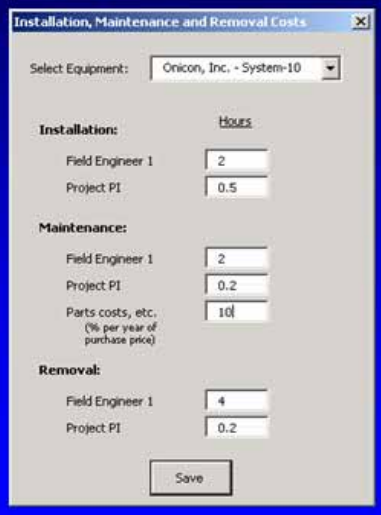
Equipment Associated Labor



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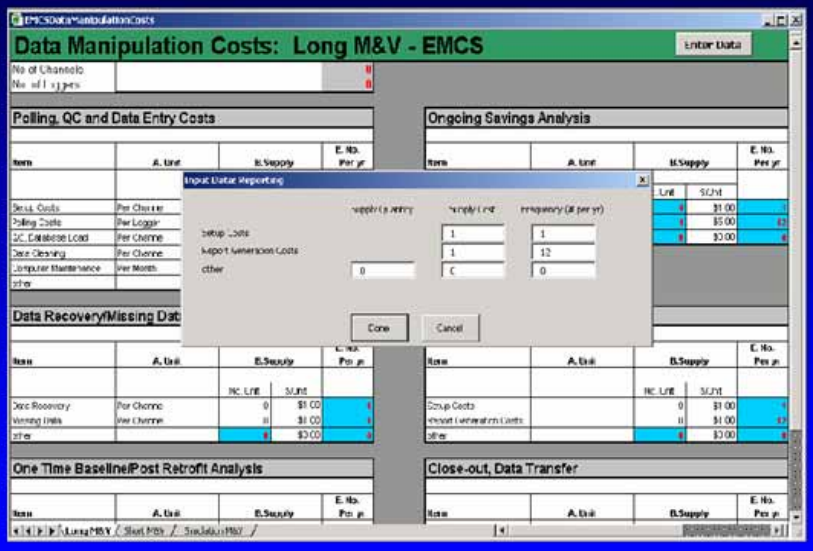
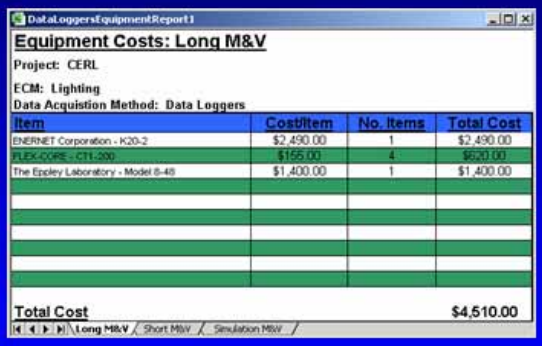
Some of the "Hidden Costs"



Report Generation

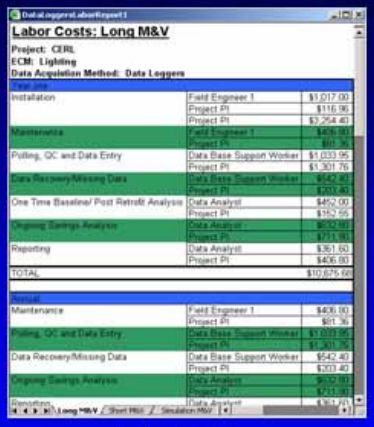
Reports

Total Summary



Equipment Detail

Detailed Category Reports



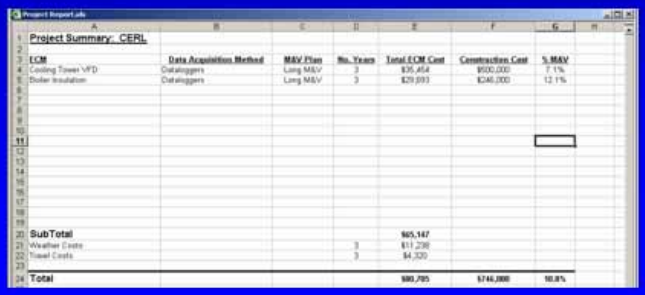
Labor Detail

Travel Detail

Weather Detail

Annual Detail

Project Summary Reports



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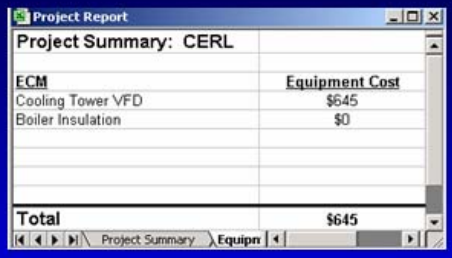
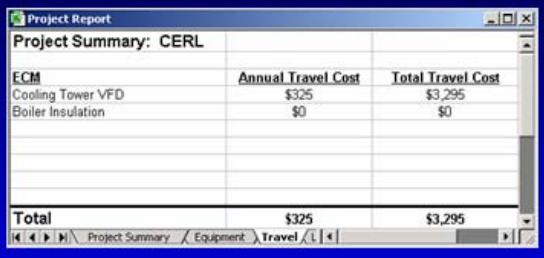
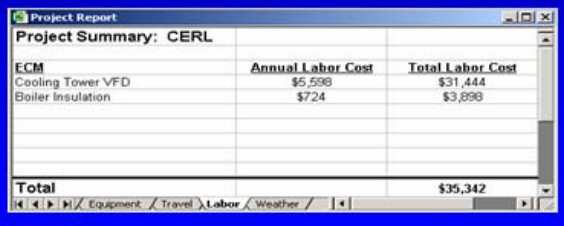
Project Summary Reports By ECM







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How To Get It

- **Web site:** http://www.cecer.army.mil/mvtoolkit
  - Cost Tool
  - Users Manual
  - Tutorial
  - Example Projects: Lighting. Future: Chiller Replacement, Boiler Replacement, EMCS. 3 Examples Each
  - Links to other M&V sites
- **Copy CD**
- **Give me a business card**

Future Of The Tool

- Examples Will Be Put On Web Site
- CERL Has No Plans For Future Development or Support
- Others Encouraged To Use It and Make Enhancements

NIST/FEMP BLCC5 Building Life-Cycle Cost Program

Presenter: Dr. Sieglinde Fuller. NIST.

BLCC5

- Java Program
  - **platform-independent, web-friendly**
  - **program-integrated help**
- Annual Updates
  - **energy price projections, discount rates**
  - **legislative requirements, user requests**
- Technical Assistance
  - **training**
  - **telephone and e-mail support**
  - **free download**

BLCC5 Modules

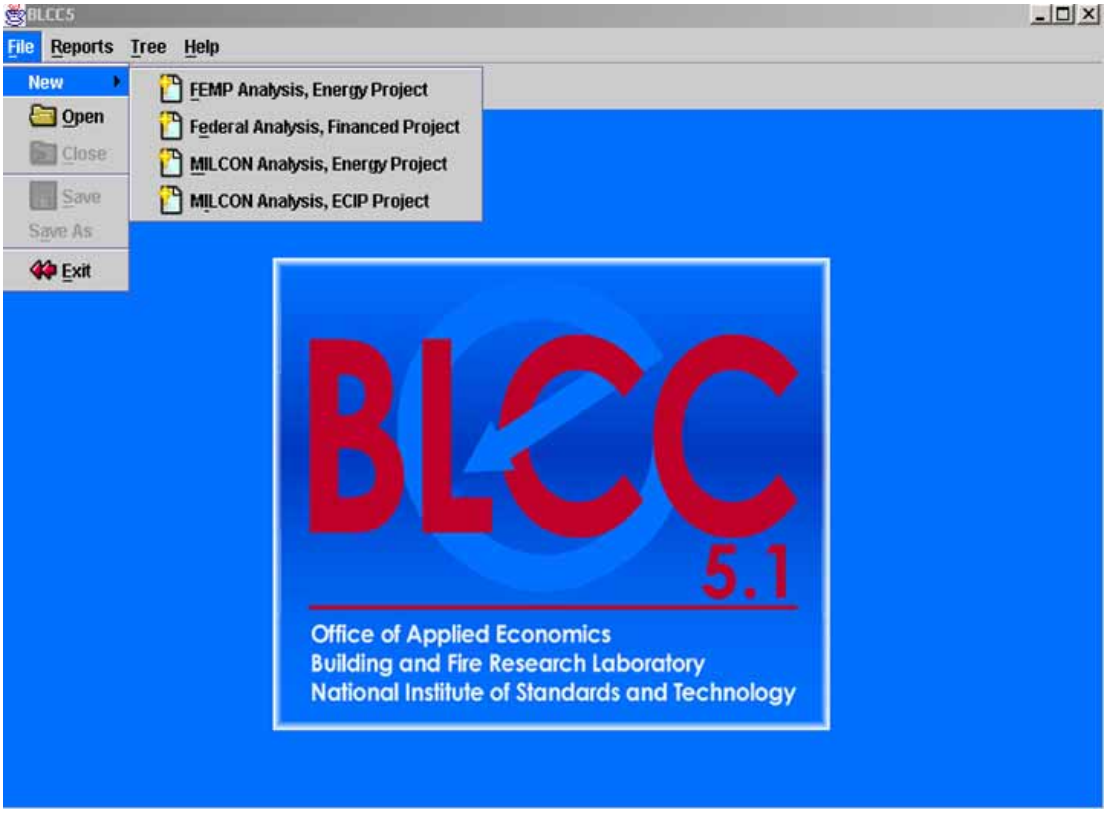
- FEMP – 10 CFR 436A
  - Energy and water conservation and renewable energy projects
- MILCON – DoD Criteria/Standards for LCCA
  - Energy and water conservation projects
  - ECIP projects
- OMB – Circular A-94
  - non-energy: cost effectiveness, lease/purchase,
  - internal govt. inv., asset sale analysis.
- ALTERNATIVE FINANCING - EO 13123
  - ESPC and UESC projects

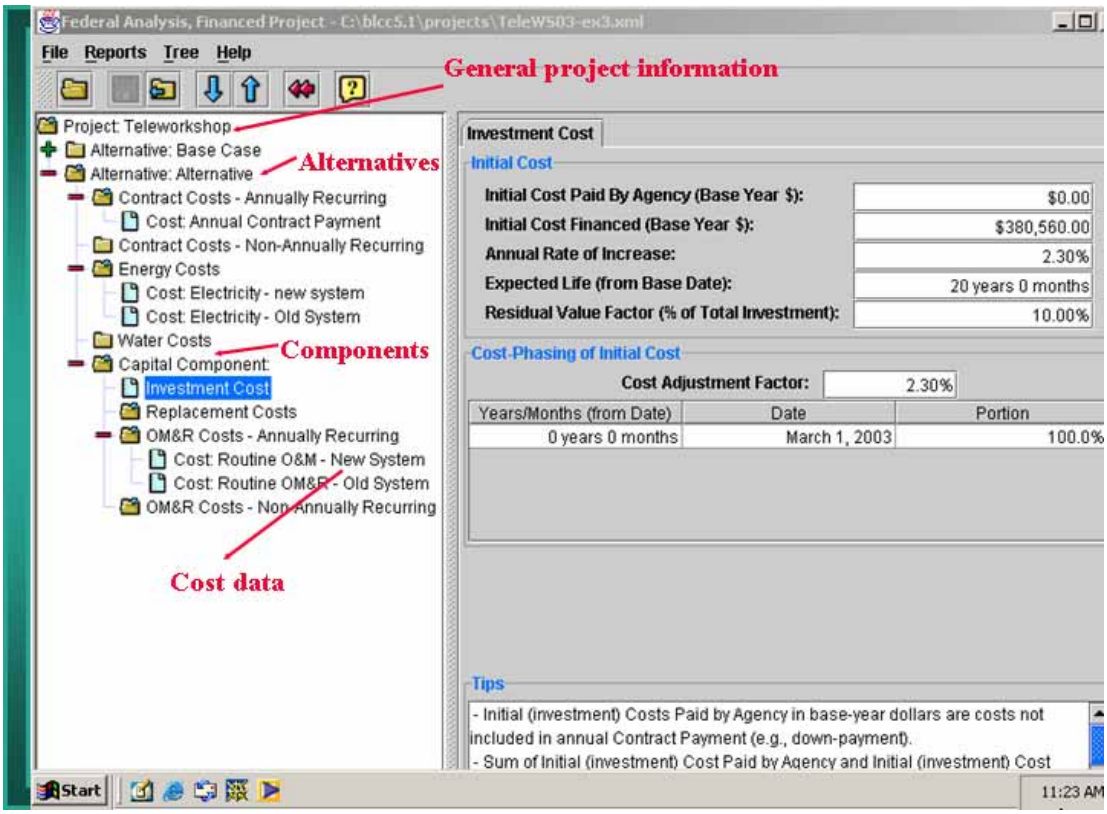
BLCC5 - ESPC Example

Replace existing lighting system in a federal office building in Arizona with a new system financed through an ESPC

Amount financed:	$380,560
Contract payments:	$58,000
Study period:	20 years
Contract period:	10 years
Implementation period:	1 year

Determine whether the proposed system is cost-effective and whether the expected savings cover the contract payments.

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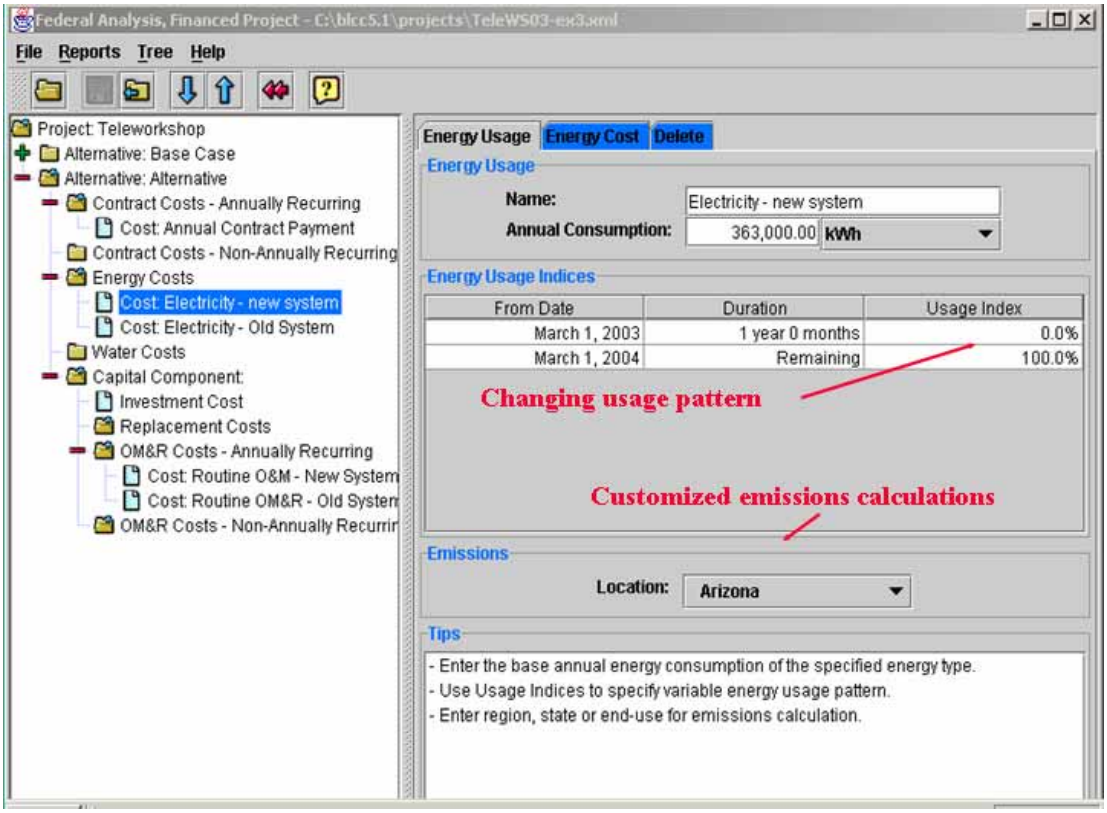
File Reports Tree Help
General project information
Project: Teleworkshop
Alternative: Base Case
Alternative: Alternative
Alternatives
Contract Costs - Annually Recurring
Cost: Annual Contract Payment
Contract Costs - Non-Annually Recurring
Energy Costs
Cost: Electricity - new system
Cost: Electricity - Old System
Water Costs
Components
Capital Component:
Investment Cost
Replacement Costs
OM&R Costs - Annually Recurring
Cost: Routine O&M - New System
Cost: Routine OM&R - Old System
OM&R Costs - Non-Annually Recurring
Cost data
Investment Cost
Initial Cost
Initial Cost Paid By Agency (Base Year $): $0.00
Initial Cost Financed (Base Year $): $380,560.00
Annual Rate of Increase: 2.30%
Expected Life (from Base Date): 20 years 0 months
Residual Value Factor (% of Total Investment): 10.00%
Cost-Phasing of Initial Cost
Cost Adjustment Factor: 2.30%
Years/Months (from Date) Date Portion
0 years 0 months March 1, 2003 100.0%
Tips
- Initial (investment) Costs Paid by Agency in base-year dollars are costs not included in annual Contract Payment (e.g., down-payment).
- Sum of Initial (investment) Cost Paid by Agency and Initial (investment) Cost
Start
11:23 AM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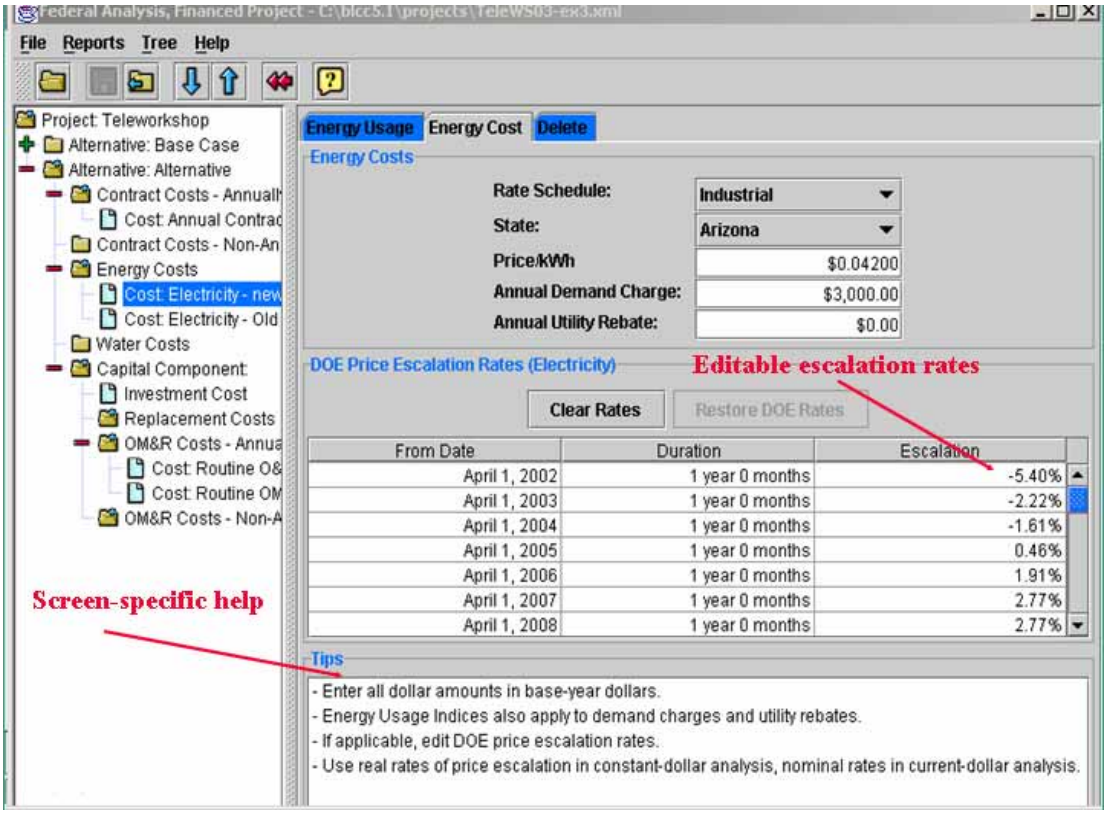
Cost: Routine O&M - New System
Cost: Routine OM&R - Old System
OM&R Costs - Non-Annually Recurring
Energy Usage
Energy Cost
Delete
Energy Usage
Name: Electricity - new system
Annual Consumption: 363,000.00 kWh
Energy Usage Indices
From Date Duration Usage Index
March 1, 2003 1 year 0 months 0.0%
March 1, 2004 Remaining 100.0%
Changing usage pattern
Customized emissions calculations
Emissions
Location: Arizona
Tips
- Enter the base annual energy consumption of the specified energy type.
- Use Usage Indices to specify variable energy usage pattern.
- Enter region, state or end-use for emissions calculation.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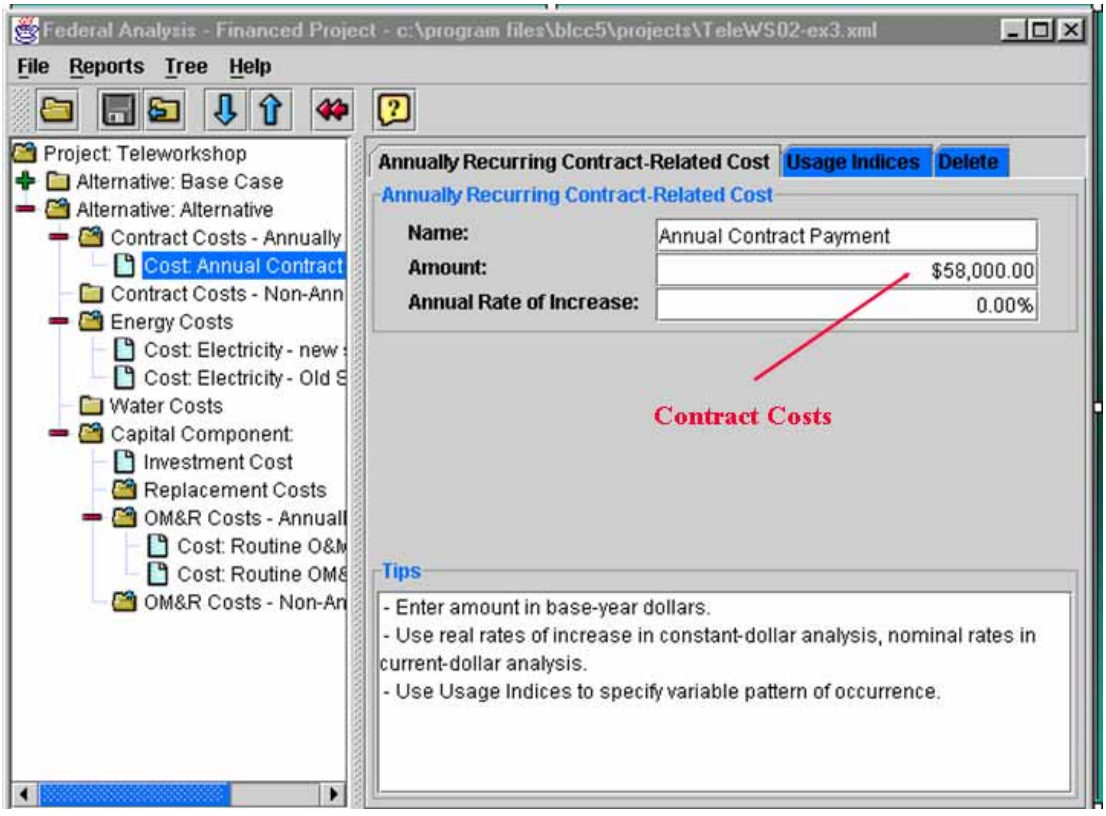
Delete
Energy Costs
Rate Schedule:
Industrial
State:
Arizona
Price/kWh
$0.04200
Annual Demand Charge:
$3,000.00
Annual Utility Rebate:
$0.00
DOE Price Escalation Rates (Electricity)
Editable escalation rates
Clear Rates
Restore DOE Rates
From Date
Duration
Escalation
April 1, 2002
1 year 0 months
-5.40%
April 1, 2003
1 year 0 months
-2.22%
April 1, 2004
1 year 0 months
-1.61%
April 1, 2005
1 year 0 months
0.46%
April 1, 2006
1 year 0 months
1.91%
April 1, 2007
1 year 0 months
2.77%
April 1, 2008
1 year 0 months
2.77%
Screen-specific help
Tips
- Enter all dollar amounts in base-year dollars.
- Energy Usage Indices also apply to demand charges and utility rebates.
- If applicable, edit DOE price escalation rates.
- Use real rates of price escalation in constant-dollar analysis, nominal rates in current-dollar analysis.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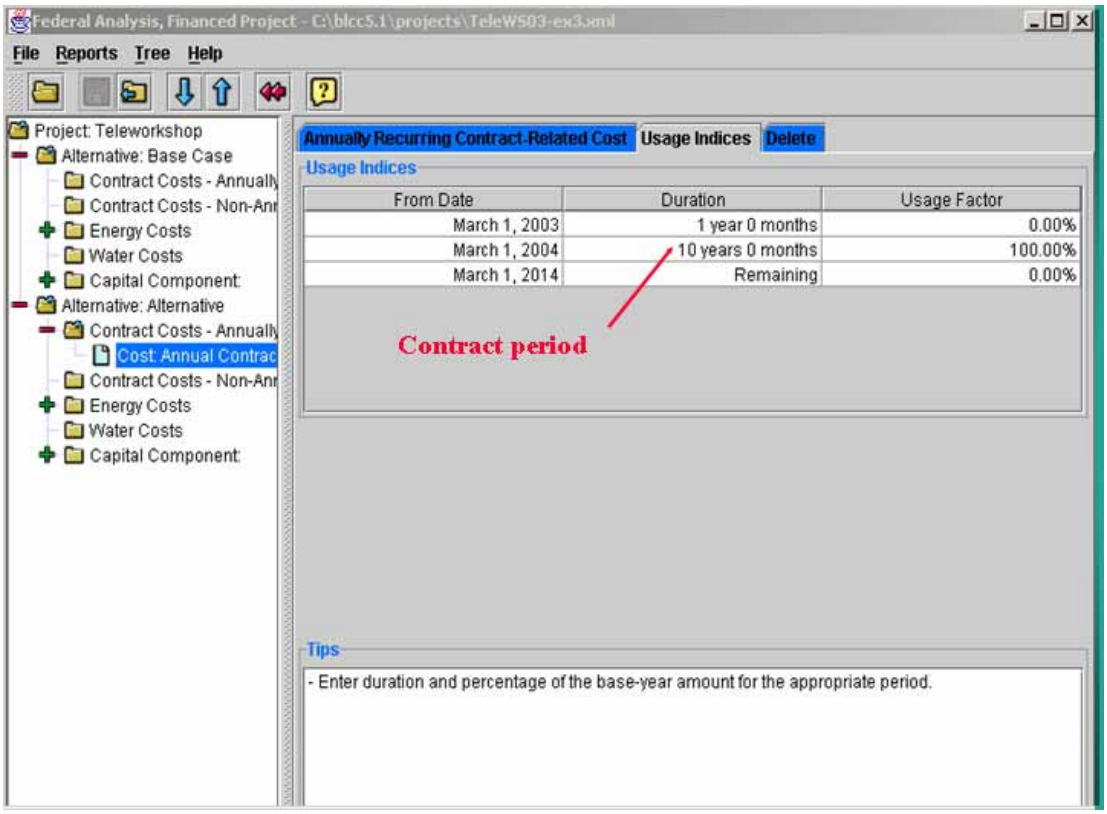
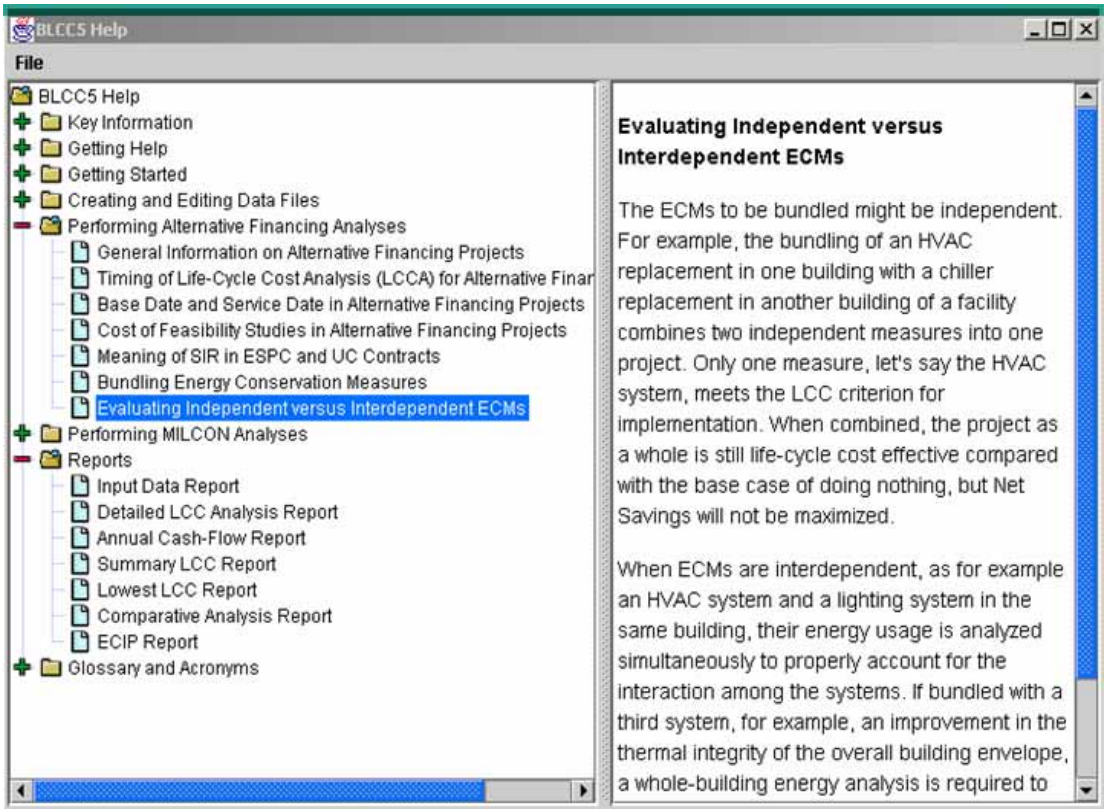
Cost: Routine O&M
Cost: Routine OM&
OM&R Costs - Non-An
Annually Recurring Contract-Related Cost
Usage Indices
Delete
Annually Recurring Contract-Related Cost
Name:
Annual Contract Payment
Amount:
$58,000.00
Annual Rate of Increase:
0.00%
Contract Costs
Tips
- Enter amount in base-year dollars.
- Use real rates of increase in constant-dollar analysis, nominal rates in current-dollar analysis.
- Use Usage Indices to specify variable pattern of occurrence.


Federal Analysis, Financed Project - C:\blcc5.1\projects\TeleW503-ex3.xml
File Reports Tree Help
Project: Teleworkshop
Alternative: Base Case
Contract Costs - Annually
Contract Costs - Non-Anr
Energy Costs
Water Costs
Capital Component:
Alternative: Alternative
Contract Costs - Annually
Cost: Annual Contrac
Contract Costs - Non-Anr
Energy Costs
Water Costs
Capital Component:
Annually Recurring Contract-Related Cost
Usage Indices
Delete
Usage Indices
From Date
Duration
Usage Factor
March 1, 2003
1 year 0 months
0.00%
March 1, 2004
10 years 0 months
100.00%
March 1, 2014
Remaining
0.00%
Contract period
Tips
- Enter duration and percentage of the base-year amount for the appropriate period.


BLCC5 Help
File
BLCC5 Help
Key Information
Getting Help
Getting Started
Creating and Editing Data Files
Performing Alternative Financing Analyses
General Information on Alternative Financing Projects
Timing of Life-Cycle Cost Analysis (LCCA) for Alternative Finar
Base Date and Service Date in Alternative Financing Projects
Cost of Feasibility Studies in Alternative Financing Projects
Meaning of SIR in ESPC and UC Contracts
Bundling Energy Conservation Measures
Evaluating Independent versus Interdependent ECMs
Performing MILCON Analyses
Reports
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Detailed LCC Analysis Report
Annual Cash-Flow Report
Summary LCC Report
Lowest LCC Report
Comparative Analysis Report
ECIP Report
Glossary and Acronyms
Evaluating Independent versus Interdependent ECMs
The ECMs to be bundled might be independent. For example, the bundling of an HVAC replacement in one building with a chiller replacement in another building of a facility combines two independent measures into one project. Only one measure, let's say the HVAC system, meets the LCC criterion for implementation. When combined, the project as a whole is still life-cycle cost effective compared with the base case of doing nothing, but Net Savings will not be maximized.
When ECMs are interdependent, as for example an HVAC system and a lighting system in the same building, their energy usage is analyzed simultaneously to properly account for the interaction among the systems. If bundled with a third system, for example, an improvement in the thermal integrity of the overall building envelope, a whole-building energy analysis is required to

File

NIST BLCC 5.1-02: Lowest LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\blcc5.1\projects\TeleWS03-ex3.xml
Date of Study:	Fri Dec 20 16:07:37 EST 2002
Analysis Type:	Federal Analysis, Financed Project
Project Name:	Teleworkshop
Project Location:	Arizona
Analyst:	SKF
Comment:	Replace existing lighting system with new lighting/daylighting system
Base Date:	March 1, 2003
Study Period:	20 years 0 months (March 1, 2003 through February 28, 2023)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Lowest LCC

Comparative Present-Value Costs of Alternatives
(Shown in Ascending Order of Initial Cost, * = Lowest LCC)

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)
Base Case	$0	$1,025,226
Alternative	$0	$700,797 *

Comparative Analysis Report

File

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$0	$0	$0
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$412,058	-$412,058
Energy Consumption Costs	$787,356	$240,057	$547,300
Energy Demand Charges	$153,381	$47,125	$106,257
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$84,489	$21,727	$62,762
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$20,170	$20,170
Subtotal (for Future Cost Items)	$1,025,226	$700,797	$324,429
Total PV Life-Cycle Cost	$1,025,226	$700,797	$324,429

File

Comparison of Contract Payments and Savings from Alternative
(undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Mar 2003	$0	$0	$0	$0
Mar 2004	-$58,000	$52,960	$58,820	$820
Mar 2005	-$58,000	$52,792	$58,787	$787
Mar 2006	-$58,000	$53,521	$59,654	$1,654
Mar 2007	-$58,000	$54,819	$61,093	$3,093
Mar 2008	-$58,000	$56,222	$62,640	$4,640
Mar 2009	-$58,000	$57,421	$63,987	$5,987
Mar 2010	-$58,000	$58,969	$68,031	$10,031
Mar 2011	-$58,000	$58,729	$65,601	$7,601
Mar 2012	-$58,000	$59,352	$66,381	$8,381
Mar 2013	-$58,000	$60,463	$67,654	$9,654
Mar 2014	$0	$61,729	$65,145	$65,145
Mar 2015	$0	$63,238	$66,732	$66,732
Mar 2016	$0	$64,778	$68,352	$68,352
Mar 2017	$0	$66,195	$72,602	$72,602
Mar 2018	$0	$67,709	$71,450	$71,450
Mar 2019	$0	$69,147	$72,974	$72,974
Mar 2020	$0	$70,454	$74,368	$74,368

Savings exceed costs

File

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	1,100,000.0 kWh	399,930.7 kWh	700,069.3 kWh	13,999,468.9 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	3,753.4 MBtu	1,364.6 MBtu	2,388.7 MBtu	47,768.2 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	895,922.17 kg	325,667.71 kg	570,254.46 kg	11,403,527.89 kg
SO2	1,097.86 kg	399.07 kg	698.79 kg	13,973.87 kg
NOx	2,926.84 kg	1,063.91 kg	1,862.93 kg	37,253.58 kg
Total:				
CO2	895,922.17 kg	325,667.71 kg	570,254.46 kg	11,403,527.89 kg
SO2	1,097.86 kg	399.07 kg	698.79 kg	13,973.87 kg
NOx	2,926.84 kg	1,063.91 kg	1,862.93 kg	37,253.58 kg

Limitations

- No calculation of contract payments
- No monthly payments
- No import/export feature
- Emissions factors not editable
- No designated sensitivity analysis module
- Non-energy modules still to be added

Resources

- Energy Escalation Rate Calculator
- NIST Handbook 135
- FEMP/NIST LCC Workshops
  - Basic Workshop
  - Project-Oriented Workshop
  - Teleworkshop
- NIST Training Videos

Contacts

- **BLCC, associated programs and user guides:** http://www.eere.energy.gov/femp - Technical Assistance - Analytical Software Tools
- **Handbook 132 and Annual Supplement:** 1-800-DOE-EREC (1-800-363-3732)
- **Technical Assistance:**
  NIST Office of Applied Economics
  LCC Method: sieglinde.fuller@nist.gov, 301-975-6134
  Software: amy.rushing@nist.gov, 301-975-6136